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TECHNICAL AND TACTICAL OPPORTUNITIES FOR REVOLUTIONARY ADVANCES IN RAPIDLY DEPLOYABLE JOINT GROUND FORCES IN THE 2015-2025 ERA

VOLUME V
TRAINING DOMINANCE PANEL REPORT

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CONFLICT OF INTEREST

Conflicts of interest did not become apparent as a result of the Panel s recommendations.

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13. ABSTRACT (Maximum 200 words)

The Army Science Board was tasked to seek revolutionary possiblities for improving deployability as well as effectiveness of future joint ground combat forces. The study focused on the possibilities inherent in the Future Combat System(FCS) and also considered enhancements possible through the Future Transport Rotorcraft (FTR). Study efforts were conducted by four major Panels analyzing: Operations, Information Dominance, Sustainment and Support, and Training. The study concludes: 1) the FCS concept is sound, but senior level attention is required to ensure technologies are ready for 2006 FCS EMD; and 2) Key technologies will significantly improve force projection and combat power.

The Training Panel was asked to investigate: 1) Army Training challenges in the 2015-2025 timeframe; 2) C4ISR Training Issues; 3) Sensor-to-shooter Training Issues; 4) Distance Learning opportunities; 5) Opportunities for Embedded Training.

Respective findings include: 1) Army will need to train "Very Complex Tasks" and there is little research on how to do it; 2) C4ISR training can be both an enabler and Achilles heel of FCS effectiveness; 3) Very Complex Tasks will need to be trained at lower echelons; 4) Distance Learning should be "train as you fight" for FCS force; 5) All FCS should have Network-Centric training.

Recommendations include: FCS Training Capability should be established as a Key Performance Parameter (after Operational Performance) in Milestones II/III; The Army should task ARI and STRICOM to establish FCS Training R&D lab to develop and promote expertise in training very complex tasks; The Army should develop an initial virtual, distributed, man-in-loop emulation; and, The Army should integrate FCS training (DL, embedded training, C4ISR, sensor-to-shooter) into the Tactical Infosphere.

14. SUBJECT TERMS
Training Dominance, Future Combat System, FCS, Embedded Training, Networked Training, Sensor-to-Shooter, Very Complex Tasks, Distance Learning, DL, Tactical Infosphere, FCS Training, Future Combat System Training

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- Volume I - Executive Summary
- Volume II - Operations Panel Report
- Volume III - Information Dominance Panel Report
- Volume IV - Support and Sustainment Panel Report
- Volume V - Training Dominance Panel Report

If you received only the Executive Summary, the additional volumes may be reviewed and/or downloaded by visiting

http://www.saalt.army.mil/sard-asb/ and clicking on Studies .

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era

Training Dominance Panel Report

Table of Contents

TRAINING DOMINANCE PANEL

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era

July 27, 2000

17 - 27 July 2000
ASB Summer Study Session
Newport Beach, CA

Page 1
4/12/01 15:19
version 14

Co-chairs for the Training Dominance panel were:

Dr. Harry O Neil
MG(R) Chuck Drenz
RADM(R) Fred Lewis

Principal Staff Assistant was Ms. ChØrie Smith.

Training Dominance Has Been and Will Continue to Be the Key to Victory

In the recent past:

- Train as we fight has been the key
- Desert Storm 100-hour war proved U.S. training dominance

In the future:

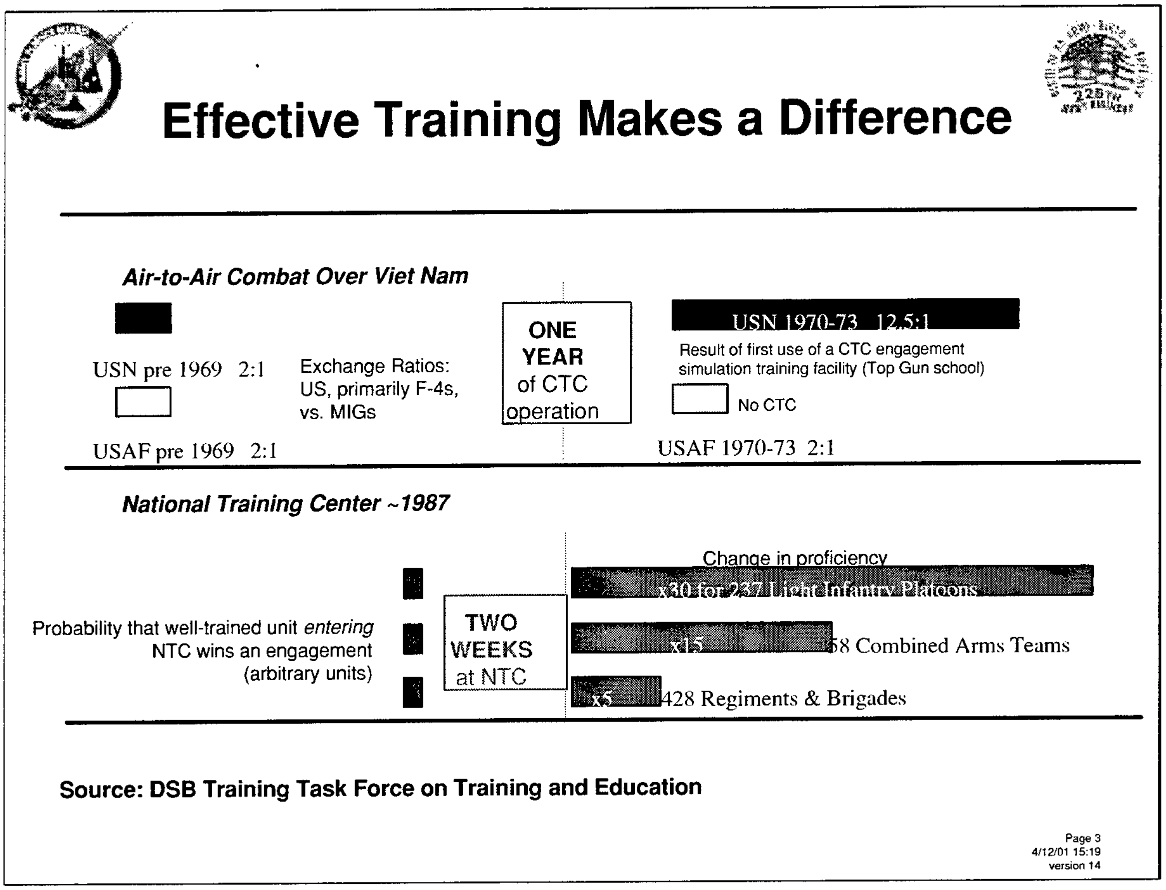
- Anyone (including our enemies) can acquire Commercial Off the Shelf (COTS) tools and systems
- Our preeminent training and intense continuous practice will be the discriminator and ensure our dominance on the battlefield

Page 2
4/12/01 15:19
version 14

Throughout history, studies have shown that the most prepared force has almost always been victorious. Mission accomplishment and loss rates are directly correlated to training and preparedness.

Fighting as we train and training as we fight have been key functions in U.S. Armed Forces engagements. The speed at which our Desert Storm forces accomplished their objectives is a good recent example.

In the future, navigation precision, satellite imaging, and information technology tools will be more available to everyone through commercial channels. As a result, it will be critical for us to be preeminent in our approaches to develop and deliver training to our troops. This will provide the ultimate discriminator in ensuring our dominance on the battlefield.



Information in this chart is from the Defense Science Board Task Force on Training and Education. Dr. Braddock Co-Chaired this Summer Study with several ASB Members (e.g., Dr. Harry O Neil).

The results of U.S. tactical engagement simulations, as measured by changed performance at the National Training Center, are as spectacular as the Top Gun influence on the air war over Viet Nam. For example, training for ground combat increased the odds of winning an offensive mission by 30:1 for light infantry platoons as measured over 237 trials, by 15:1 for combined arms teams as measured in 58 trials, and 5:1 for regiments or brigades (428 trials).

Gorman (1995) op. cit., Chart titled U.S. Army Tactical Engagement Simulation attributed to Dr. R.H. Sulzen, ARI, 1987

Also, the best paper at this year s MORS Conference, entitled Why Skill Matters in Combat Outcomes: and How to Include it in Combat Modeling by Fischerkeller, Hinkle, and Biddle, makes that point that in analysis of historical battles, Armies possessing the higher level of skill won regardless of differences in technology.

Today s Presentation Is Organized Around Terms of Reference

Questions	Key Findings
What training challenges will the Army face in the 2015-2025 era and how can it meet them?	**Army will need to train very complex tasks; very little research on how to do it**

What are the training issues in the C4ISR area?

What are the training issues for sensor-to-shooter employment?

What are the opportunities for distance learning?

What are the opportunities for embedded training?

Page 4
4/12/01 15:19
version 14

This briefing is organized, based on the Terms of Reference in question format, coupled with key findings, followed by a summary and concluding with recommendations.

Changes in Forces and Missions Will Increase Task Performance Requirements

Adaptive behavior

Reasoning

Judgment

Operations under ambiguity and stress

More team/collective tasks

~15% of tasks can be described as very complex

Page 5
4/12/01 15:19
version 14

Approximately 15 percent of the tasks can be described as very complex. This percentage is based on expert opinion. Similar percentage exists in the Navy. An analysis is needed of what percentage of tasks are very complex in current training versus in FCS to see if the problem is getting worse. To do the analysis, a standard definition of Very Complex task is required. It is likely that the percentage of very complex tasks will increase in the FCS.

Examples of Very Complex Tasks

Manage C2 of direct and indirect fire robotic systems

Conduct teleoperated robotic navigation

Control anti-jamming networks

Ensure network security for C2 of distributed robotic systems

Control robotic sensors

Page 6
4/12/01 15:19
version 14

Shown on this chart are examples of very complex tasks. The tasks are modified from a draft concept paper by Terry D. Faber, Army Training Support Center, Enhanced Embedded Training, 7/14/00. In this scenario, an operator determines where high-speed robots must navigate and chooses anti-jamming frequencies and networks based on recent intelligence information. During control of the robotic system, the operator must assess information from other sensors supporting the operation as to reliability and counter measures effects. The operator must select responses with other operators. The operator must perform Battle Damage Assessments and respond appropriately.

Characteristics of Very Complex Tasks Make Them Hard to Teach

Very Complex Tasks are:

- **Abstract, multi-variate, continuous, nonlinear, dynamic, interactive, simultaneous, conditional**
- **Shared across individuals and teams: e.g., undersea warfare, joint task force coordination, sensor-to-shooter employment/tactics, network-centric collaboration, and C4ISR**

Many of these tasks require 5-20 years of experience to develop expertise

Consequence of poor individual or team performance is catastrophic

Solving this problem has very high payoff!

Page 7
4/12/01 15:19
version 14

1) Abstract tasks are harder to teach than concrete and linear ones (small inputs yield large outputs).

2) CHARACTERISTICS OF VERY COMPLEX TASKS

Abstract	Objects or principles are associated to define form rather than absolute content.
Multi-variate	Many variables affect outcomes.
Continuous	The phenomena varies without lapse, rather than as discrete properties.
Non-Linear	Future results cannot be directly inferred from past performance. Sometimes, small changes in input yield very large effects.
Dynamic	Interactions are time dependent.
Interactive	A variable value is dependent on changes in other variables. Processes within a domain may be strongly codependent.
Simultaneous	Processes occur at the same time.
Conditional	Boundaries under which processes operate.

3) 5 to 20 years can be reduced with focused practice through simulation.

There Is a Need for Some More Capable People to Perform Very Complex Tasks

- Increased skill levels
- Higher aptitude
- Greater seniority
  - 5-20 years to develop expertise
- Critical mass of skilled team leaders
- Handle the stress of critical decision making across an expanded battlefield

Critical issue is how many people needed with these characteristics

Page 8
4/12/01 15:19
version 14

Very complex tasks have an impact on the Army s personnel requirements. Higher skill and aptitude levels are needed for soldiers assigned to these military specialties involving very complex tasks. The length of time necessary to build needed levels of expertise will require changes in unit structures to allow progression in responsibility as skills are developed. A critical mass of skilled team leaders will need to be developed over time. Expertise will allow future soldiers to operate at high levels under the stress of the future expanded battlefield.

Technology Is a Double-Edged Sword

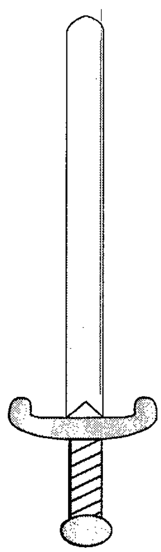
Pro

Automates tasks

Reduces the number of soldiers and weapon systems to perform the tasks

Provides intelligent assistants (robots)

Expands battle space



Con

Increases workload

Increases the skill level of soldiers needed

Requires training for degraded mode

Increases need for perishable training

Page 9
4/12/01 15:19
version 14

Technology has the capability to reduce complexity by automation of functions currently allocated to soldiers. However, technology is two-edged. The positives are that soldiers have fewer tasks to perform. However, in the past, automation of functions has frequently had an opposite effect as designers have added new functions to the human s workload. An example of this is the design of the front seat of the Apache Helicopter. Automation can also reduce the number of soldiers required to operate the system, but the soldiers that are needed will usually require higher aptitude levels. Automation can simplify system operation when the automated systems are operating. But soldiers training requirements may not be reduced accordingly, because they also must be trained on how to perform their tasks as the automated systems degrade and the tasks that remain will require frequent practice to maintain high performance

Future Soldiers Will Be Digital Learners Also Double-Edged

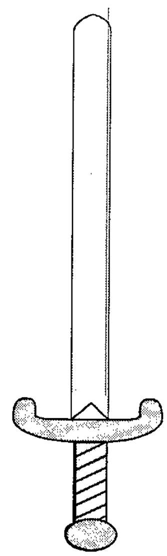
Pro

Multiprocessing

Extensive effort on enjoyable tasks

Computer fluency

Bias to action



Con

Varied attention span

Some Army tasks are not enjoyable

Reflection is not a tendency

Page 10
4/12/01 15:19
version 14

Future soldiers will come to the Army with long experience using computers and playing complex computer games. This also is a dual-edged sword. These young people will be quite adept at playing games that require high skill levels in multi-processing and eye-hand coordination. They spend long hours honing their skills, very much enjoying the experience. The games bias them to act, to keep up with the game s rapid pace. On the negative side, future soldiers are likely to have attention spans that will vary depending on the ease with which they achieve high levels of skill and on how much they enjoy the experience.

Brown, J. S. (2000). Growing up digital. How the Web changes work, education , and the ways people learn. Change, 32(2), 11-20.

Minimal Research on Critical Training Problems

Army R&D on training is minimal, approximately $50M this year

- Army Research Institute ($10M); Army Research Lab ($15-20M); STRICOM ($10M); STRICOM/Institute for Creative Technologies ($10M)

Industry has little R&D in training

- Mostly product research
- Few research labs that conduct basic research do less today

University-based training R&D also limited

- Educational research is minimally funded and focused on K-12

Some help from best-in-class companies (models) & American Society for Training & Development (analytic work)

Page 11
4/12/01 15:19
version 14

All told, Army R&D on training amounts to $50 Million this year: The Army Research Institute for Behavioral and Social Sciences ($10M for Training R&D); Army Research Lab ($15-20M); STRICOM ($10M/6.2 funds); STRICOM/Institute for Creative Technologies (ICT) ($10M). ICT is based at University of Southern California and is a joint University/Entertainment Industry/Army effort to dramatically improve the Army s simulation and training capability.

Few Research Labs: Bell Labs, Xerox, and others have in the past resourced training research. The ability of industry to fund this type of work has declined as their emphasis has moved from basic technology development to product-oriented research.

University-based training research is limited. The services continue to fund some research, but dollar amounts are small. Educational research at the K-12 grade levels is not necessarily relevant to the Army population of adult learners.

Questions and Key Findings

Questions	Key Findings
What training challenges will the Army face in the 2015-2025 era and how can it meet them?	Army will need to train very complex tasks; very little research on how to do it
What are the training issues in the C4ISR area?	**C4ISR training is both an enabler and the Achilles heel of FCS effectiveness**
What are the training issues for sensor-to-shooter employment?	
What are the opportunities for distance learning?	
What are the opportunities for embedded training?	

In the dynamic battlefield environment of the future, C4ISR functions will be critical to the FCS success. The speed and sheer volume of information may overwhelm and inundate the FCS operators and decision-makers. The information must be integrated and filtered (fused) appropriately.

Consequently, intense C4ISR training is key to having our operators proficient in the leading-edge FCS capabilities and tools. Without this proficiency, our FCS system will decay into an expensive array of ineffective hardware and software.

The Environment for Conducting C4ISR in 2015 Will Be Very Different

C4ISR information will be available and used at a much lower level (from Corps to Company)

- Increase in decision making at lower levels under stressful conditions
- Dramatic increase in amount and complexity of information
- Is it an Aviation (Warrants) or an Armor (NCOs) personnel model?

The tasks will be very complex

- Draw appropriate inferences from displays
- Ask the right questions to pull down information

Page 13
4/12/01 15:19
version 14

Tremendous differences in the C4ISR environment will be in effect by 2015. Today, almost all the assessment of intelligence information and tactical decision-making is performed at the Theater/CORPS/Division levels (some at Brigade). Threat scenarios are developed separate from the force and provided to them, resulting in a long cycle time. The current interactions between Corps and Company level create a cycle time that will be completely unacceptable in 2015.

Besides training in the C4ISR area, which is at the leading edge of technology advancements, we are moving the operating level down from the Theater/Corps to the Company. This amounts to an explosion of nodes and people who need to be trained in this critical C4ISR area.

A question that must be addressed is what kind of FCS personnel model we should have. Should it be a model that emphasizes the use of Warrant Officers (as in the Aviation Branch) or one that emphasizes the use of NCOs (as in the Armor Branch)?

To some degree, this decision will be based on what level the C4ISR will be done and what cost will be acceptable. Many more decision options will exist and the people making these decisions will be at a much lower level. Because we will be operating at a lower tactical level, the decision-making timeline will be severely compressed. The number of nodes will multiply and collaboration will be at a premium. The soldier at the company level must be capable and trained to draw appropriate inferences from the multiple C4ISR displays and, be able to frame the right questions to get the needed information.

Training Will Be Crucial in Achieving FCS/C4ISR Performance Expectations

Training subsystem must be embedded and available for multi-mission use

- **Mission preparation and rehearsal (home station, in-route, in-theater)**
- **Learn/practice individual and collaboration skills**
- **Knowledge Management System incorporates cognitive modeling, predictive prognostics (e.g., anticipatory logistics)**

Training must be collaborative and plug-and-play

Page 14
4/12/01 15:19
version 14

Training will be among the greatest vulnerabilities in executing the FCS mission. To ensure we meet FCS expectations, the training subsystem must be an inherent part of the FCS design and development. The training must be embedded into the platform/system and must be an organic part of the deployed capability. Availability on a continuous basis, in both collective and individual modes, will be critical to establishing the level of proficiency required.

The concept of embedded training allows real-time, on-demand mission rehearsals, both in theater and in a reach-back connection to CONUS. Distance learning enables us to learn and practice both individual and collaborative skills. There is a fundamental linkage required to a Knowledge Management system that provides a gateway to required and relevant information.

A critical component of the knowledge management system is a predictive diagnostics function. This idea is based on an analogy from Caterpillar Company s ability to predict failure of its equipment and ship parts worldwide before the equipment fails so that the needed part is available when the original part fails. Likewise, the knowledge management system should know each soldier s knowledge, skills, and attitudes such that with a new mission, training can be provided for projected needed individual skills before collective mission rehearsal.

The use of the same all-source intelligence information as provided to the fighting forces is paramount to FCS success. Migration to an intense collaborative environment in a networked plug-and-play scheme will be useful to break out of the current stovepiping mentality.

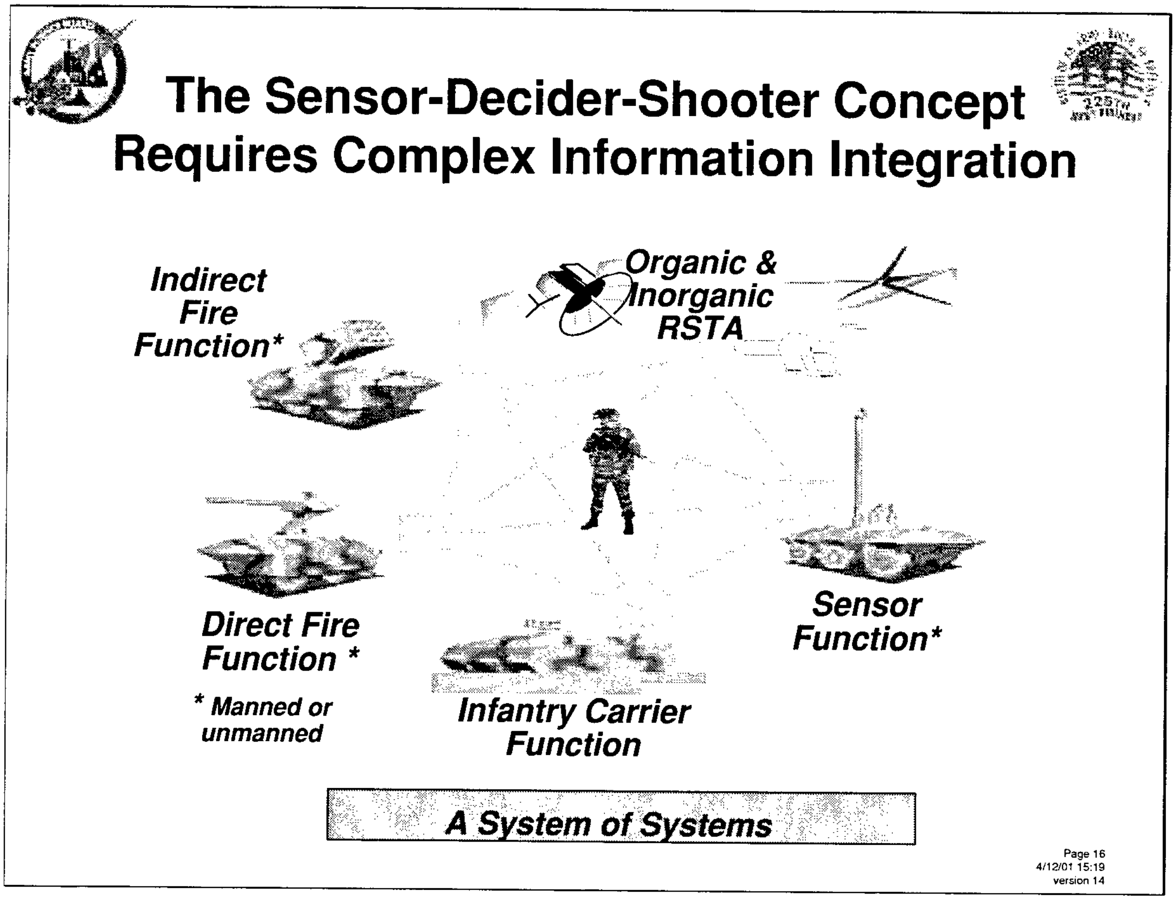
Questions and Key Findings

Questions	Key Findings
What training challenges will the Army face in the 2015-2025 era and how can it meet them?	Army will need to train very complex tasks; very little research on how to do it
What are the training issues in the C4ISR area?	C4ISR training is both an enabler and the Achilles heel of FCS effectiveness
What are the training issues for sensor-to-shooter employment?	**Very complex tasks need to be trained at lower echelons**
What are the opportunities for distance learning?	
What are the opportunities for embedded training?	

Page 15
4/12/01 15:19
version 14

The key finding is the sensor-to-shooter employment is that such very complex tasks will need to be trained at lower echelons.

The main issue in sensor-to-shooter employment is training the decision maker. For this reason, we refer here to sensor-decider-shooter (rather than just sensor to shooter) issues. This framework is based on a TRADOC framework of this issue. These issues require use and integration of an expanded range of sensor and weapon capabilities. These will be employed from both other Services and from Army sources. Their use will require operational and training concepts that will be new to the Army. They will require abstract, higher order cognitive processes at progressively lower echelons.



The Shooter-Decider-Shooter concept requires complex information integration. In the slide, the soldier/leader is the focus. We view this issue as a system of systems.

It is also an example of what we have been calling a very complex task. The soldier or crew in the middle is no longer required to master a single weapon and specific target, but must deal with a whole array of both weapons and sensor capabilities at levels of abstraction that are heretofore unprecedented. Adding all these new modalities and alternatives creates training and operational requirements that grow explosively through their many combinations in complexity with each added possibility.

Sensor-to-shooter operations will become increasingly complex and will pose formidable training challenges. Extensive knowledge and substantial inferential capability are required to interpret sensor data, generate hypotheses about their meaning, and propose courses of action, particularly when multiple sensors, weapons, and tactical situations are involved. All of these tasks require deep understanding of the functional properties being sensed, the operation and limitations of sensors, and the environmental or real-world interactions that affect data observation and interpretation. Further complexity is encountered in most warfare applications as intelligent opponents seek to avoid detection, confuse identification, and gain tactical advantage by employing intelligent countermeasures or unconventional maneuvers to make sensor employment even more difficult.

Sensor-Decider-Shooter Concept Requires Very Complex Tasks at Lower Levels

Today, sensor-to-shooter functions are partitioned
- **e.g., Forward Observer - Fire Direction Center - Battery**

Future sensor-decider-shooter functions will be controlled by the war fighting unit

The decider function entails very complex tasks
- **Sensor choice, deployment, interpretation, integration**
- **Rules of Engagement interpretation, application**
- **Target detection, identification, selection**
- **Weapons mix, direction, engagement**
- **Assess effect and re-engage**

. . . and it must get done in less time over a larger combat space at lower levels

Page 17
4/12/01 15:19
version 14

Today, sensor-to-shooter functions are partitioned -- e.g., Forward Observer -- Fire Direction Center -- Battery.

Future sensor-decider-shooter functions will be controlled by the war fighting unit.

In effect, the intelligence in the system is in the Fire Direction Center.

The very complex tasks required by sensor-decider-shooter operations include the following:

Processing information from numerous independent sources located on the ground, in the air, or in space

Assessing the reliability of information received, keeping in mind all variables that may affect reliability

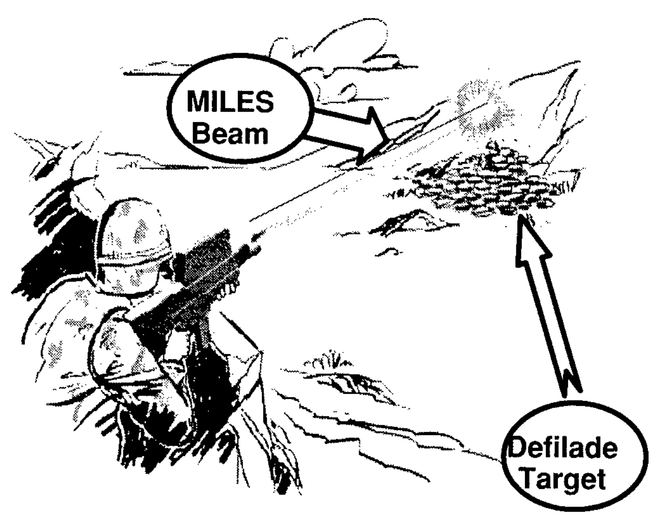
Selecting targets appropriate for the operational rules of engagement

Selecting appropriate weapon system response measures -- again as they are appropriate for the operational rules of engagement

Coordinating these responses with other shooters

Assessing results and responding appropriately

New Training Concepts Are Needed to Facilitate Sensor-Decider-Shooter Training



- New training capability for reasoning, interpretation, and decision tasks
- Training for collaborative decision making and shared situational awareness at home station
- Sensor-decider-shooter simulation and live training to exercise full range of complexity
- New indirect precision fires instrumentation to augment traditional line-of-sight laser equipment at CTCs and home station

Page 18
4/12/01 15:19
version 14

Training must help in (1) retaining the capability to perform conventional sensor and combat tasks; and (2) expanding capability to perform new technology sensor-decider-shooter tasks. New training is necessary to develop the knowledge required to deal with varied targets in more complex environments,

This requires improved basic understanding of how different types of sensors (including those from other Services) work, what they can see when they can see, what kinds of error or ambiguity are associated, and what types of counter measures the enemy can use to negate them. (Navy sonar training research applies to how to train these tasks.)

The soldier must also understand the employment of a wider range of weapons, including their limitations and collateral effects.

Shared situational awareness and collaborative decision making with other individuals, units, echelons and services is required. It is very difficult to train these skills, so a significant R&D program is necessary to determine best training methods.

Knowledge is not enough; there must be practice. Thus, advanced simulations and live-fire CTC-type exercises are essential. They must be specifically designed to require, measure, and feed back information on the full range of sensor-decider-shooter skills. In this regard, improved instrumentation for training ranges is also essential.

Finally, CTC-type exercises will also develop doctrine and command/control concepts needed for successful operations.

Questions and Key Findings

Questions	Key Findings
What training challenges will the Army face in the 2015-2025 era and how can it meet them?	Army will need to train very complex tasks; very little research on how to do it
What are the training issues in the C4ISR area?	C4ISR training is both an enabler and the Achilles heel of FCS effectiveness
What are the training issues for sensor-to-shooter employment?	Very complex tasks need to be trained at lower echelons
What are the opportunities for distance learning?	**DL should be Train as you fight for the FCS force**
What are the opportunities for embedded training?	

Page 19
4/12/01 15:19
version 14

In the previous slides, we have discussed training challenges. The next section treats opportunities. DL should be a train-as-you-fight for the FCS force.

The number one modernization goal of the U.S. military is digitization of processes and organizations to achieve information dominance. However, to take advantage of the myriad of new digital systems, soldiers must be prepared to operate them effectively. Distance learning has the potential to dramatically enhance organizational performance by increasing personnel qualifications in the unit and reducing the impact of skill decay by making training available when and where required. The ability to conduct pre-deployment, mission specific training under the tutelage of skilled subject-matter experts can result in faster preparation for contingencies.

The single most important opportunity is to Train as We Fight by creating a network-centric, collaborative training environment. The proliferation of low-cost personal computers capable of rendering high-quality graphics, adoption of international standards for multimedia conferencing, and the ubiquity of network access have resulted in the opportunity to train as we fight by creating affordable, effective, networked training environments. These training environments should provide the opportunity for knowledge-based, mentored, collaborative training of all soldiers, teams,and units to include operations, maintenance, and leadership functions.

Current DL Program Will Not Produce Right Lessons Learned for FCS

Institutional paradigm

- Goodness is number of students, not unit readiness or performance support
- Predominately dedicated, high-cost, high-bandwidth, brick-and-mortar learning center approach

No integration with or enabling of C4ISR systems (administrative, strategic, or tactical)

Extremely long lead times for courseware adaptation and development (18-36 months); no systematic integration of GOTS, COTS courseware

No program to rapidly evaluate and integrate evolving learning methodologies and technologies

Correct now for immediate payoff

Page 20
4/12/01 15:19
version 14

The current Army distance learning program continues the institutional paradigm where the measure of merit is the number of students trained, not unit readiness or performance support. The strategy of this program leads to dedicated, high-cost, high-bandwidth brick-and-mortar centers to achieve focus on high-bandwidth video for real-time learning. This focus ignores many low-cost, highly accessible, highly interactive, collaborative technologies and results in high costs and a relatively small improvement in accessibility. Accessibility of distance learning in soldiers and units is further reduced by lack of integration with, or enabling of, administrative, tactical, or strategic C4I systems.

Relevancy of the entire program is reduced by extremely long lead times and costs for courseware adaptation, along with lack of systematic integration of government off the shelf (GOTS) and commercial off the shelf (COTS) courseware or courseware developed for new equipment training (NET).

The current institutional learning management system has limited applicability for planning, assessing, and executing training in support of unit readiness.

The lack of a formal program to rapidly evaluate and integrate evolving learning methodologies and technologies severely limits the capability of the system to keep pace with change in the commercial, government and academic communities.

Interneting among the teams in the FCS will enable knowledge-based, mentored, reach-back, collaborative distance learning. Teams should be able to rehearse and mentor down to the individual soldier level, regardless of physical location.

To Train As You Fight, DL Needs the Following Elements

VISION: A virtual community of learners, trainers, and training content in which soldiers engage the content and collaborate with peers and mentors anytime, anywhere, at any pace

A C4ISR infrastructure that includes an embedded training environment

A family of low-cost augmentations/interfaces to provide learning interactions over C4ISR

Cutting-edge learning methodologies and technologies rapidly assimilated into unit performance support system

Learning Community Management System incorporating cognitive modeling, anticipatory prognostics, and resulting recommended remedies

Page 22
4/12/01 15:19
version 14

The elements here are driven by our overarching vision for the future of learning. In this vision, we see a virtual community of learners, trainers, and training content, which includes simulations and other course lesson materiel in which the soldiers can engage the content and freely collaborate with peers and mentors anytime, at anywhere, at any pace. In this vision, we are talking about the creation of a learning ecosystem that is analogous to the Tactical Infosphere for the FCS. We should shift the priority of investment from the institutional school house paradigm to focus on unit readiness training. The evaluation of the training system effectiveness should be on relationship to unit readiness and empowering of commanders, NCOs, and soldiers above student throughput.

Since the best way to train a distributed, collaborative force is in a distributed, collaborative training environment, the training doctrine for all echelons of the Army should be executed through a distributed, collaborative network. The FCS C4ISR system should be designed and built with the requirement to distribute training. That network should also provide for a family of low-cost augmentations/interfaces to enable learning interactions. The Army should leverage investments and increase access now by delivering distance learning over and to administrative and strategic C4I systems. For example, since current C4I networks are not robust enough for high bandwidth real-time events over single media, we should ensure simultaneous access for all learners, regardless of bandwidth service, by using hybrid environments that distribute the communication load over multiple, low-bandwidth communications media. These training environments are especially applicable for real-time collaborative coaching of leaders, operators,and maintainers.

The Army should dramatically increase partnerships with other governmental and non-governmental organizations to increase access and decrease courseware fielding time. We should immediately institute systematic integration of courseware and modules from COTS, GOTS, and New Equipment Training (NET) sources, while dramatically streamlining the development and delivery process for on-demand learning.

As we enter the new millenium, innovative learning tools for training continue to evolve and expand. The proliferation of Web courseware technologies, as well as the addition of clever technologies to deliver content to remote sites, multiply the opportunities and challenges facing training environments (Gray, 1999). The effectiveness of these new training approaches and technologies, however, must be assessed and rapidly assimilated into practice to maximize return. We recommend establishing a training laboratory program to rapidly assimilate best of breed, emerging methodologies, and technologies into operational use.

We also propose development and fielding of a comprehensive, seamless learning management system reaching across all domains and locations. This learning management system should incorporate cognitive modeling, prognostics, and recommended remedies to create mass customization of the learning experience based on situation, learning styles, and available technologies. This should also enable the equivalent of an electronic training job book containing the status and history of cognitive performance for each soldier, team, and unit.

Questions and Key Findings

Questions	Key Findings
What training challenges will the Army face in the 2015-2025 era and how can it meet them?	Army will need to train very complex tasks; very little research on how to do it
What are the training issues in the C4ISR area?	C4ISR training is both an enabler and the Achilles heel of FCS effectiveness
What are the training issues for sensor-to-shooter employment?	Very complex tasks need to be trained at lower echelons
What are the opportunities for distance learning?	DL should be Train as you fight for the FCS force
What are the opportunities for embedded training?	**All FCS should have network-centric training**

Page 24
4/12/01 15:19
version 14

The key finding is that all FCS should have network-centric training.

There are major programmatic opportunities for future embedded training and a host of technological breakthroughs that we can leverage.

The programmatic opportunities are the FCS and the new Reconnaissance Surveillance and Target Acquisition (RSTA) system. The FCS could provide the opportunity to analyze the benefits of various models of a Future Operational Training System architecture. This opportunity requires articulation with FCS initiatives or we will lose the creativeness of a joint/integrated initiative.

The future RSTA is another opportunity to create and analyze the benefits of a distributed nodal embedded trainer. Clearly, the difficulty will be the software constructs and data constructs required to be embedded.

Future technical breakthroughs will produce massive data storage capabilities in very small envelopes that require very little power. With such storage capabilities, Mission Engagement scripts can be embedded in platforms without a penalty for weight, space, and power in the same envelope. The combination of storage and computational power breakthroughs will greatly facilitate network-enabled training.

Few Legacy Systems Have Embedded Platform-Centric Training

Degree of Embedding	Description	Example
Fully Embedded	All elements of training system embedded in end-item	Patriot
Appended	Elements of training system are attached/ removed when needed	M2A3
Umbilical	Same as appended but depends on remote/external components	MILES/AGES Equipment Simulation System GUARDFIST Tank Gunnery System

Page 25
4/12/01 15:19
version 14

Few current/legacy systems have embedded training. The few that do have varying degrees of embedded training. These are categorized into 1) fully embedded, 2) appended, and 3) umbilical. Fully embedded training features are built into the primary system-enabling the user through software or courseware to simulate a scenario with operational characteristics.

Appended training is installed or attached to the primary system when needed and removed when not needed. It can be appended or strapped to the operational equipment, but is essentially self-contained.

Umbilical is similar to appended; however, it involves connections to external independent components or systems. This requires specific components to be built into the operational equipment for the purpose of training.

Author: Army Training Support Center, Title: Enhanced Embedded Training, (EET) 14 July 2000, POC: Terry D. Faber, Commercial (757) 878-3969

The Future Is Network-Centric Training Systems

Characteristics	Description	Example
Physical Structure **Nodal**	**End item is a sub-component (one node) of a training system**	**National Military Intelligence Center Watch Group**
Physical Access **Wireless**	**End item has wireless access to external components of a training system**	**Force XXI Battle Command Brigade and Below as a software agent**
Construct **Emulation**	**High-fidelity replication of actual system**	**Inter Vehicular Info System Training on PC**
Simulation	**Functional replication of actual system**	**Close Combat Tactical Trainer**
Stimulation	**Generation of stimuli for end item devices**	**Joint Simulation System**

The future of training systems is based upon the networking of all systems. When viewed in this light, platform-centric training loses its appeal. It is much more effective to network all systems together to achieve larger-scale, more realistic training.

Training systems will be composed of individual platforms, where each weapon system is viewed as a node in the training system. This defines the structure of future training systems to be nodal. The preferred means of access to these training system components will be wireless. This allows for more flexibility in creating the specific set of weapon systems to be included in any given training system on any given day.

Training systems themselves will still be constructed from the approaches listed here. Emulated systems are training systems that are designed to exactly mimic the system they are emulating, e.g., the Inter Vehicular Information System (IVIS) trainer for the M1A2. This IVIS trainer is an emulator of the IVIS system that replicates the M1A2 communications functionality on a workstation that realistically trains without the actual M1A2 equipment. Simulated systems are training systems that are functionally equivalent, though not necessarily identical, to the systems they are simulating. For example, when a pilot enters a flight simulator, he or she sees the controls and instruments, feels the sensations of flying, etc., but no one is confused about the fact that they are not in an actual aircraft. Stimulation systems are systems that receive external stimuli from some generating source for training purposes and then respond as if this stimulation input were real; indeed, from the systems point of view, stimulated input is the same as real input.

Network-Centric Training Systems Capabilities

Training Capability	Use
Networked Engagement Simulation	Reduces required systems Integrates live training capability with system
C4ISR Mission Rehearsal	Enables mission planning/rehearsal capability

Page 27
4/12/01 15:19
version 14

The areas listed above represent critical training requirements for the Objective Force in the field and/or garrison. The tempo of projected operations implies an up-tempo training requirement. The complexity of projected company level operations implies a higher stressful operational and training environment.

Summary: Key Findings

Questions	Key Findings
What training challenges will the Army face in the 2015-2025 era and how can it meet them?	Army will need to train very complex tasks; very little research on how to do it
What are the training issues in the C4ISR area?	C4ISR training is both an enabler and the Achilles heel of FCS effectiveness
What are the training issues for sensor-to-shooter employment?	Very complex tasks need to be trained at lower echelons
What are the opportunities for distance learning?	DL should be Train as you fight for the FCS force
What are the opportunities for embedded training?	All FCS should have network-centric training

Page 28
4/12/01 15:19
version 14

This slide summarizes our key findings. As you may remember, we focused this brief in terms of questions and key findings. For example, all FCS should have network-centric training.

Key Recommendations

Establish FCS training as a second-priority Key Performance Parameter (KPP) after operational performance in Milestones II/III

Resource Army Research Institute/STRICOM to develop an FCS R&D laboratory to promote expertise for very complex tasks

- **New capabilities for reasoning, interpretation, problem solving, decision making**
- **Training for collaborative problem solving and decision making and shared situational awareness**
- **Comprehensive, performance-based training management system, including metrics and instrumentation**
- **Simulation, live-training, mission planning and rehearsal capabilities to exercise full range of complexity**

Page 29
4/12/01 15:19
version 14

The FCS will be the cornerstone of the Army s future combat power. It is imperative that training be integrated into its development from the outset. Too often in the past, training is relegated to a future time, after development, or funds originally earmarked for training are used for development. As a consequence, training is added-on or not available when the system is fielded. Given the likely complexity of the FCS, training must have a higher priority during development, second only to operational performance. This will ensure that the systems developed are trainable, with embedded, network-centric capabilities, and are able to prepare the soldier to fight from the day the first unit is equipped.

The FCS will demand that soldiers possess expertise in very complex tasks. We currently do not know enough about what the soldier will need to know, or the most effective means for training the soldier. It is imperative that the appropriate agencies, and we recommend the Army Research Institute and STRICOM, be resourced to conduct this research. Example of the kinds of R&D needed are:

(1) We will need to obtain (recruit) or develop (train) smarter soldiers, i.e., we need new capabilities for training, reasoning, interpretation, problem solving, and decision making. What are the most effective means for doing this?

(2) We need new strategies and techniques for training across wide distances and varying skill levels and equipment. Training systems will also need to support collaboration in problem solving and development of shared situational awareness between nodes on the FCS network. Networked distance learning capabilities need to be exploited.

(3) We need a comprehensive training management system with appropriate metrics and instrumentation. What should be in this system? How is data captured? These are the kinds of questions that need to be answered.

(4) The FCS will have many capabilities and will be responsive to multiple missions across wide distances. Learning to train with an integrated exercise of simulated and live forces and equipment, including mission planning and rehearsal capabilities, is a very complex task in itself. How should these capabilities be best captured to achieve a broad mission?

Key Recommendations
(continued)

Develop an initial virtual, distributed, man-in-loop emulation

- Joint Army-DARPA contributions
- Can be used to define training requirements and evaluate alternative training system

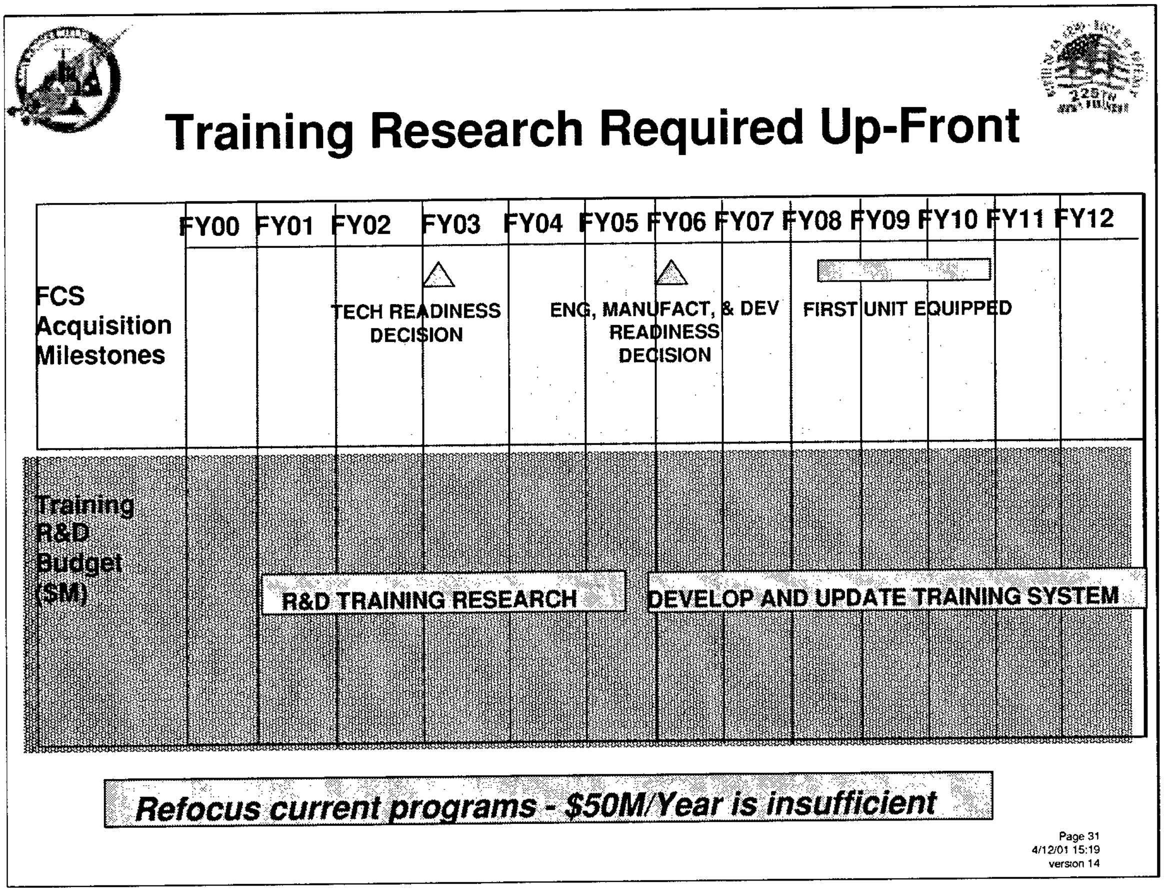
Integrate FCS training (DL, embedded training, C4ISR, sensor-to-shooter) into the Tactical Infosphere

- C4ISR as enabler
- Network-centric DL supports FCS home station and deployment training

Page 30
4/12/01 15:19
version 14

To best understand what capabilities will be needed in the FCS, we need to have a better understanding of how it will be employed and what its limitations and constraints will be. The best way to develop these concepts is through simulation-based acquisition. Toward that end, it is imperative that an initial virtual, distributed, man-in-the-loop emulation of the FCS be created so that what-if scenarios can be executed. This will allow the FCS developers to better understand what is needed, to examine alternatives, and to experiment with tactics, techniques, and procedures for the FCS. We can use this simulation to define FCS training requirements and evaluate alternative training systems. It seems logical to use a collaborative effort between Defense Advanced Research Project Agency (DARPA) and the Army to accomplish this, given DARPA s interest in this project and the synergy of these two agencies in the initial effort to develop the FCS. Further, we recommend that this initial effort be undertaken as soon as possible in the very near term to achieve its maximum benefit.

Training for the FCS needs to be integrated into the Tactical Infosphere. This training must be composed of all four elements: Distance Learning, embedded training, C4ISR, and sensor-to-shooter. We see C4ISR as an enabler of the training and network-centric distance learning as a mechanism. This would allow FCS training to be available whether at the home station, at a CTC, during deployment, or in theatre. One can envision a virtual community of learners/soldiers, trainers, and training content in which soldiers can engage the content and collaborate with peers and mentors anywhere, anytime, at any pace.



Training research is required up-front. The R&D training research must be accomplished by FY05 to support the FCS acquisition milestones. The training development for FCS training of very complex tasks would be initiated in FY06. We did not estimate the R&D budget required as we did not conduct an analysis of the existing programs. However, it is clear to our panel members that the $50 million per year is insufficient. Secretary Mike Andrews plans to conduct a review of existing programs in the Human Sciences area during Fall 2000.

Workgroups

C2/Intel: Assess the command and control systems ability to provide necessary alternative mission analyses and threat scenario generation using all source intelligence.

Frank Figueroa Work Group Chair — Dave Raes Back up for Chair
Peter Lee — Susan G. Lowenstam

Embedded Training: Feasibility of embedding necessary training system requirements in the Future Army Land and Aviation Vehicles, to include mission rehearsal capabilities.

Warren Morrison - Work group Chair — Tom Moore
Steve Goldberg — Bob Whartenby
Sandy Wetzel-Smith — Chuck Engle
Fred Lewis — Chuck Drenz

Sensor-to-Shooter Employment: Training requirements necessary to train the sensor-to-shooter precision fires employment.

Mike Macedonia - Work Group Chair — Michael Farmer — Dexter Fletcher

DL: Need and feasibility of using distance learning techniques to train portions of the force with Out of Theater resources.

Mike Freeman - Work group Chair — Irene Peden — Jim Ralph
Phil Spence — John Miller

Page 32
4/12/01 15:19
version 14

Backup

Site Visits

Simulation Training and Instrumentation Command
- Mr. Jim Skurka, Deputy Commander

Central Command
- LTG Mike Dodson, Deputy Commander in Chief

Army Research Institute
- Dr. Barbara Black, Chief Armored Systems Research

Training Doctrine Command
- MG John Sylvester, Deputy Chief of Staff Training
- Colonel Bob Reddy, Commander Army Training Support Command

Institute for Creative Technologies (University of Southern CA)

HQDA Deputy Chief of Staff Operations
- BG James Lovelace, Former Director of Training
- BG Tom Webster, Director of Training

HQDA Deputy Chief of Staff Personnel
- BG Mike Rochelle, Special Assistant to the DCSPER

Army Research Institute for Environmental Medicine
- Colonel D. M. Penetar, Director

Deputy Chief of Staff Intelligence
- Colonel J. Karcz, Foreign Intelligence
- Colonel Dave Pyle, Exec

Universal Studios

Page 34
4/12/01 15:19
version 14

Training Panel Members

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Mr. Francisco Figueroa
Dr. Mike Freeman
BG Mike Haugen
RADM(R) Fred Lewis
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Mr. Tom Moore
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Dr. Irene Peden
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Ms. ChØrie Smith
Dr. Gershon Weltman
Mr. Bob Whartenby

Panel Support:

Dr. Paul Steinberg
Cadet Mike Lohrenz
Mr. Gary Winkler

APPENDIX A

TERMS OF REFERENCE

DEPARTMENT OF THE ARMY
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ACQUISITION LOGISTICS AND TECHNOLOGY
103 ARMY PENTAGON
WASHINGTON DC 20310-0103

REPLY TO
ATTENTION OF

February 28, 2000

Mr. Michael J. Bayer
Chair, Army Science Board
2511 Jefferson Davis Highway, Suite 11500
Arlington, Virginia 22202

Dear Mr. Bayer:

I request that you conduct an Army Science Board (ASB) Summer Study on "Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era." The ASB members appointed should consider these Terms of Reference (TOR) as guidelines and may include in their discussions related issues deemed important or suggested by the sponsors. Modifications to the TOR must be coordinated with the ASB office.

I envisage that this work by the Army Science Board will also yield practical near term insights and opportunities that will assist the Army Leadership in focusing priorities for our limited research, development and acquisition accounts to create the most combat effective and cost efficient rapidly deployable joint ground forces for the 2015-2025 period.

The study should be composed of four parallel investigations leading to an integrated set of recommendations. This work is to be guided by, but not limited to, the following lines of inquiry:

Team 1 - Operations. To the goal of achieving rapidly deployable forces with dominant maneuver supported by precision fires, look at those opportunities which offer the greatest pay off for quickly deploying forces which feature a highly flexible array of full spectrum force capabilities. Focus on combat operations, accounting for capabilities required to achieve systems overmatch as a critical component of overall force effectiveness both for initial entry into a theater of operations and to enable operational maneuver within the theater once operations begin. The array of systems and force capabilities should assure future commanders retain battlefield freedom of maneuver and are not denied tactical options for offensive or defensive schemes of maneuver. While combat operations are the focus, the relevance of the capabilities to stability and support operations, such as peace operations, should be assessed. Consider, but do not limit your investigation to the following opportunities:

a. Look at the feasibility of synchronizing the requirements for the Future Combat System, the Joint Transport Rotorcraft (JTR), and Comanche to provide revolutionary tactical and theater mobility and increased strategic mobility. If feasible, what are the assumed tactical benefits of this union?

b. Assess the capabilities gained by exploiting robotic air and ground systems as reconnaissance/surveillance, attack systems, and other functions. Which force capabilities or platforms appear to benefit most from this relationship?

c. Propose a suite of smart munitions/sensor combinations in our direct fire and indirect fire forces that offer the most cost effective investment and the most decisive outcome in expected scenarios.

d. Determine those areas of the force that demand robust 24 hours a day, 7 days a week manning, and portray the benefits of various manning arrangements.

e. Identify the optimal organizational structures that best exploit future information technology.

f. Determine the need for or utility of an Advanced Theater Transport (ATT) to replace the C-130 to support the operational capability and systems described above.

Team 2 – Sustainment and Support. To the goal of providing this force a support/sustainment capability with significantly reduced logistic burden, look at the opportunities in providing forces with significantly greater systems reliability (including mechanical, electronic, photonic reliability, etc.) along with graceful degradation and ultrareliability leading to simplified battlefield maintenance, repair and diagnostics/prognostics (including disposable/expendable components/systems), significantly smaller fuel and ammunition tonnage requirements, improved battlefield medical support, transport means (manned and unmanned), and remote services. Consider, but do not limit your investigation to the following opportunities:

a. Assess the opportunities to leave outside the theater significant logistic, intelligence, and administrative support, thereby reducing the force requiring in-theater support.

b. Assess the opportunities for advanced power plants that reduce the specific fuel consumption at least 25% per HP delivered.

c. Assess the logistic implications of the alternative families of smart munitions (as generated by Team 1).

d. Exploit the opportunity for remote surgery (telemedicine) to reduce the number of in-country specialty surgeons.

e. Assess the capability of the JTR to contribute to rapid medical treatment and evacuation along with other joint force options.

f. Assess the opportunities to improve the Army's capability to conduct Near Shore/Logistics-Over-the-Shore operations.

Team 3 - Information Dominance. To the goal of providing this force Information Dominance through the provisioning of an advanced "central nervous system" to meet the needs of our forces and to deny the threat force basic information needs consider at least two perspectives. First is the broad, relatively global C4ISR focus that flows vertically from the Joint Task Force down through corps and divisions (as units of employment) all the way to units of action executing their tactical operations and tasks. The second perspective includes the time sensitive information at the local level that is dependent on rapidly changing battle command and control, "around the next hill/corner" situational awareness, and the needs at the tactical maneuver/support units and teams level - platforms and organic sensors centric. This assessment should consider both of these complementary perspectives. The objective of providing maneuver units a fundamental capability to expand their engagement envelopes to include short timeline, beyond line of sight and fleeting targets may provide a catalyst for this information dominance challenge. Look at capabilities which provide digital map location and terrain elevation data to support the needs of ground maneuver commanders and precision fires employment, yield superior situational awareness of friendly and threat forces, instantaneous critical logistic asset status and location, theater missile threat detection, location and ongoing tracking of any threat weapons of mass destruction, and deny the threat forces this basic capability using both lethal and non-lethal means. Provide forces with timely, reliable information updates (unit and platform level updates) to facilitate tactical and support mission planning and rehearsal during deployment and on the move. As technology opportunities are assessed, it is essential that future forces operating in urban and complex terrain environments have robust, high confidence situation awareness, across the full spectrum of military operations. Consider, but do not limit your investigation to the following opportunities.

a. Assess the suite of National and Theater sensors: overhead, air breathing, manned and robotic necessary to provide the desired data and information.

b. Assess the technological opportunity to provide necessary bandwidth for data, voice, and video requirements for the force.

c. Ascertain the requirements to deny the threat the necessary voice and data information he requires to effectively employ his forces.

d. Assess the ability to link all systems through an inter-netted system of non-line-of-sight communications.

Team 4 - Training. To the goal of ensuring that these deployed forces have an organic capability to train to peak effectiveness within the theater of operations, look at opportunities for providing embedded training devices for crew, team and small unit training; the ability to deliver training into the theater using "distance learning " opportunities; the ability to provide "mission rehearsal" capabilities as required; and the ability to permit staff and command training with sensitive intelligence products. These investigations should be grounded in a vision of a future training strategy for both collective and individual training which leverages a proper mix of live, virtual and constructive training and which is supported by an information based system of systems architecture. Consider, but do not limit your investigation to the following:

a. Assess the command and control systems' ability to provide necessary alternative mission analyses and threat scenario generation using all source intelligence.

b. Assess the opportunities for embedding necessary training system requirements in the Future Army Land and Aviation Vehicles, to include mission rehearsal capabilities. This assessment should include embedded joint training and real time cooperative training with units and systems both in and out of theater from alert through deployment and employment.

c. Assess the training requirements necessary to train the sensor to shooter precision fires employment.

d. Look at the need for and feasibility of using distance learning techniques to train portions of the force with out-of-Theater resources.

e. Investigate approaches which can link training and operational system capabilities to facilitate the creation of realistic conditions and which can store, fuse, filter and disseminate relevant information to a variety of training system components.

Study Support. Sponsors of this study are GEN John M. Keane, Vice Chief of Staff; GEN John N. Abrams, Commanding General, US Army Training and Doctrine Command; GEN John G. Coburn, Commanding General, Army Materiel Command, and LTG John J. Costello, Commanding General, Space and Missile Defense

Command. LTG Paul J. Kern is the ASA(ALT) cognizant deputy and LTG Randall L. Rigby, Jr., is the TRADOC cognizant deputy.

Schedule. The study panel will initiate the study immediately and conclude its effort at the report writing session to be conducted July 17-27, 2000, at the Beckman Center on the campus of the University of California, Irvine. As a first step, the study co-chairs will submit a study plan to the sponsors and the Executive Secretary outlining the study approach and schedule. A final report will be issued to the sponsors in September 2000.

Sincerely,

Paul J. Hoeper

Paul J. Hoeper
Assistant Secretary of the Army
(Acquisition, Logistics and Technology)

APPENDIX B

PARTICIPANTS LIST

PARTICIPANTS LIST

ARMY SCIENCE BOARD
2000 SUMMER STUDY

TECHNICAL AND TACTICAL OPPORTUNITIES FOR REVOLUTIONARY ADVANCES IN RAPIDLY DEPLOYABLE JOINT GROUND FORCES IN THE 2015-2025 ERA

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The Potomac Foundation

Dr. Marygail Brauner
RAND

LTG Paul Funk (USA, Ret.)
General Dynamics Land Systems

ASB Panel Chairs

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APPENDIX C

ACRONYMS

Acronyms

A2C2	Army Airspace Command and Control
AAC	Army Acquisition Corps
AAE	Army Acquisition Executive
AAFIF	Automated Air Facilities Information File
AARs	After Action Reviews
ABCS	Army Battle Command Systems
ABN	Airborne
ACAT	Acquisition Category
ACOM	Atlantic Command
ACR	Armored Cavalry Regiment
ACTD	Advanced Concept Technology Demonstration
ADO	Army Digitization Office
AEF	Air Expeditionary Force
AF	Air Force
AFSAB	Air Force Scientific Advisory Board
AFSS	Advanced Fire Support System
AJ	Anti Jamming
AGCCS	Army Global Command and Control System
AGS	Armored Gun System
AI	Artificial Intelligence
ALP	Advanced Logistics Project
AMC	Army Materiel Command
AMCOM	Aviation and Missile Command
AMSAA	Army Materiel Systems Analysis Activity
AOR	Area of Responsibility
APFSDS	Armor-Piercing, Fin-stabilized, Discarding Sabot
APC	Armored Personnel Carrier
APOD	Aerial Port of Debarkation
APOE	Aerial Port of Embarkation
APS	Active Protection Systems; Army Prepositioned Stocks
ARDEC	Army Research, Development, and Engineering Center
ARL	Army Research Laboratory
ATT	Advanced Tactical Transport
ARTY	Artillery
ASA(ALT)	Assistant Secretary of the Army for Acquisition Logistics and Technology
ASB	Army Science Board
ASD C3I or ASD(C3I)	Assistant Secretary of Defense (Command, Control, Communications, and Intelligence)
ASTMP	Army Science and Technology Master Plan
ASTWG	Army Science and Technology Working Group
AT	Anti Tank
ATD	Advanced Technology Demonstration
ATG	Anti-Tank Gun

ATGM	Anti-Tank Guided Missile
ATR	Automated Target Recognition
AWE	Advanced Warfighting Experiment
B2C2	Battalion and Below Command and Control
BAT	Brilliant Anti-Tank
BCIS	Battlefield Combat Identification System
BDA	Battle Damage Assessment
BDE	Brigade
BITS	Battlefield Information Transmission System
BLOS	Beyond Line of Sight
BN	Battalion
C2	Command and Control
C2E	Command Center Element
C2OTM	Command and Control On-The-Move
C2SID	Command and Control System Integration Directorate
C2T2	Commercial Communications Technology Testbed
C2V	Command and Control Vehicle
C2W	Command and Control Warfare
C3	Command, Control and Communications
C3I	Command, Control, Communications and Intelligence
C3IEW	Command, Control, Communications Intelligence and Electronic Warfare
C4	Command, Control, Communications and Computers
C4I	Command, Control, Communications, Computers and Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CASCOM	Combined Arms Support Command
CASTFOREM	Combined Arms and Support Task Force Evaluation Model
CBW	Chemical and Biological Warfare
CC&D	Concealment Camouflage and Deception
CDR	Critical Design Review
CDT	Commercially Driven Technologies
CE	Chemical Energy
CECOM	Army Communication-Electronics Command
CHP	Controlled Humidity Preservation
CINC	Commander-in-Chief
CINCTRANS	Commander-in-Chief, Transportation Command
CKEM	Compact Kinetic Energy Missile
CM	Countermeasures
CONOPS	Concept of Operations
CONUS	Continental United States
COA	Course of Action
COTS	Commercial Off-The-Shelf
CPX	Command Post Exercise

CRAF	Civil Reserve Air Fleet
CSA	Chief of Staff, Army
CSSCS	Combat Service Support Computer System
CTC	Combat Training Center
DARPA	Defense Advanced Research Projects Agency
DAS	Director of Army Staff
DAS(R&T)	Deputy Assistant Secretary for Research and Technology
DBBL	Dismounted Battlespace Battle Lab
DCS(RDA)	Deputy Chief of Staff Research Development and Acquisition
DCSD	Deputy Chief of Staff Combat Development
DCSDOC	Deputy Chief of Staff Doctrine
DCSINT	Deputy Chief of Staff Intelligence
DCSLOG	Deputy Chief of Staff Logistics
DCSOPS	Deputy Chief of Staff Operations
DDR&E	Director, Defense Research and Engineering
DE	Directed Energy
DEW	Directed Energy Weapons
DISA	Defense Information Systems Agency
DISC4	Director, Information Systems, Command, Control, Communications and Computers
DL	Distance Learning
DLA	Defense Logistics Agency
DMSO	Defense Modeling and Simulation Office
DoT	Department of Transportation
DPG	Defense Planning Guide
DPICM	Dual Purpose Improved Conventional Munitions
DS	Direct Support
DSB	Defense Science Board
DSWA	Defense Special Weapons Agency
DSP	Digital Signal Processing
DTAP	Defense Technology Area Plan
DTLOMS	Doctrine, Training, Leader Development, Organization, Materiel, and Soldiers
DTO	Defense Technology Objective
DU	Depleted Uranium
DUSA-OR	Deputy Undersecretary of the Army - Operations Research
EAD	Echelons Above Division
EFOGM	Enhanced Fiber-Optic Guided Missile
EFP	Explosively Formed Penetrator
ELINT	Electronic Intelligence
EM	Electro-Mechanical, Electro-Magnetic
EMD	Engineering and Manufacturing Development
EML	Electro-Magnetic Launch
EMPRS	En Route Mission Planning and Rehearsal System

EO/IR	Electro-Optical/Infrared
ERA	Extended Range Artillery, Explosively Reactive Armor
ETC	Electro-Thermal Chemical
EW	Electronic Warfare
F&M	Firepower and Mobility
FBCB2	Force XXI Battle Command Brigade and Below
FC	Fire Control
FCS	Fire Control Systems; Future Combat System
FCV	Future Combat Vehicle
FCVT	FCV Team
FLIR	Forward Looking Infra-Red
FOB	Forward Operating Base
FOG-M	Fiber-Optic Guided Missile
FORSCOM	Forces Command
FTR	Future Transport Rotorcraft
FSCS	Future Scout and Cavalry System
FSV	Future Scout Vehicle
FTX	Field Training Exercise
GCCS	Global Command and Control System
GCSS	Global Combat Support System
GCSS-A	Global Combat Support System Army
GIG	Global Information Grid
GIS	Global Information System
GOSC	General Officer Steering Committee
GPS	Global Positioning System
GVW	Gross Vehicle Weight
HE	High Explosive
HEAT	High Explosive Anti-Tank
HHH	Hand-Held Heat
HIMARS	High Mobility Artillery Rocket System
HMMWV	High Mobility Multi-purpose Wheeled Vehicle
HNS	Host Nation Support
HPM	High Power Microwave
HQAMC	Headquarters of the Army Materiel Command
HSS	High-Speed Shipping
HVAP	High Velocity Armor Penetrating
I2R	Imaging Infrared
IA/IW	Information Assurance/Information Warfare
ICM	Improved Capabilities Missile, Improved Capabilities Munitions
IFSAR	Interferometric Synthetic Aperture Radar
III	Integrated Information Infrastructure(s)
IO	Information Operations

IPT	Integrated Product Team
IR	Infra Red
IR&D	Independent Research and Development
ISC/R	Individual Soldier's Computer/Radio
ISR	Intelligence Surveillance Reconnaissance
IT	Information Technology
IW	Information Warfare
IWS	Individual Warfighter System
J3	Operations Directorate, Joint Staff
J4	Logistics Directorate, Joint Staff
JCF	Joint Contingency Force
JCS	Joint Chiefs of Staff
JIT	Just-in-Time
JOPES	Joint Operation Planning and Execution System
JROC	Joint Requirements Oversight Council
JS	Joint Support, Joint Staff
JSTARS	Joint Surveillance Target Attack Radar System
JTA	Joint Technology Architecture(s)
JWCA	Joint Warfighting Capability Assessment
KE	Kinetic Energy
KE/CE	Kinetic Energy / Chemical Energy
KEM	Kinetic Energy Missile
LAM	Land Attack Missile
LADAR	Laser Radar
LAV	Light Armored Vehicle
LAW	Light Anti-tank Weapon
LCLO	Low Cost Low Observable
LCMS	Laser Counter Measures System
LCPK	Low Cost Precision Kill
LIDAR	Light Detection and Ranging
LIWA	Land Information Warfare Activity
LLNL	Lawrence Livermore National Laboratory
LMSR	Large Medium Speed Roll-on/roll-off
LO	Low Observables
LOS	Line of Sight
LOSAT	Line-of-Sight Anti-Tank
LOTS	Logistics Over-the-Shore
LPD	Low Probability of Detection
LPI	Low Probability of Intercept
LRIP	Low Rate Initial Production
LTL	Less-than-Lethal
LW	Land Warrior

M&S	Modeling and Simulation
MAGTF	Marine Air-Ground Task Force
MANPADS	Man-portable Air Defense System
MANPRINT	Manpower and Personnel Integration
MAVs	Micro-Autonomous Vehicles, Micro Air Vehicles
MEM	Micro-Electro-Mechanics
MEMS	Micro Electric Mechanical System
MEP	Mobile Electric Power; Mission Equipment Package
METT-T	Mission, Enemy, Troops, Terrain, Time
MEU	Marine Epeditionary Unit
MHE	Materiel Handling Equipment
MILDEP	Military Deputy
MLRS	Multiple Launch Rocket System
MMCS	Multi-Mission Combat System
MMUAV	Multi-Mission Unmanned Air Vehicle
MNS	Mission Needs Statement
MOUT	Military Operations in Urban Terrain
MPIM	Multipurpose Infantry Munition
MPS	Maritime Prepositioning Ship
MRDEC	Missile Research, Development and Engineering Center
MSTAR	Moving and Stationary Target Acquisition and Recognition
MTI	Moving Target Indicator
MTI-SAR	Moving Target Indicator Synthetic Aperture Radar
MTMC	Military Transportation Management Command
MTMC-TEA	Military Transportation Management Command Transportation Engineering Agency
MVMT	Movement
MW	Mounted Warrior
NBC	Nuclear, Biological and Chemical
NDF	National Defense Features
NG APS	National Guard - Army Prepositioned Stocks
NGB	National Guard Bureau
NGIC	National Ground Intelligence Center
NL	Non-Lethal
NLT	No Later Than
NLW	Non-Lethal Weapons
NMD	National Missile Defense
NRAC	Naval Research Advisory Committee
NRDEC	Natick Research, Development and Engineering Center
NSA	National Security Agency
NTC	National Training Center
NVESD	Night-Vision/Electronic Sensors Directorate
O&O	Operational and Organizational
OCAR	Office of the Chief, Army Reserve

OCONUS	Outside Continental United States
ODCSOPS	Office of the Deputy Chief of Staff for Operations
OOTW	Operations Other Than War
OPM	Other People's Money
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
P3I	Preplanned Product Improvement
PAM	Precision Attack Munitions
PDR	Preliminary Design Review
PDRR	Program Definition/Risk Reduction
PEO	Program Executive Office (Officer)
PEO/3C	Program Executive Officer for Command, Control and Communications
PGM	Precision Guided Munitions
PGMM	Precision Guided Mortar Munitions
POD	Point of Debarkation
POL	Petroleum, Oil and Lubricants
POM	Proparation for Overseas Movement
POS/NAV	Position/Navigation
PREPO	pre-positioned stocks
RHA	Rolled Homogenous Armor
RHAE	Rolled Homogenous Armor Equivalent
R/S	Reconnaissance/Surveillance
RC	Reserve Component
RDA	Research Development and Acquisition
RDT&E	Research Development Testing and Evaluation
RFPI	Rapid Force Projection Initiative
RHA	Rolled Homogenous Armor
RORO	Roll-on Roll-off
RPG	Rocket Propelled Grenade
RRF	Rapid Reaction Forces
RSTA	Reconnaissance Surveillance, Target Acquisition
S&T	Science and Technology
SA	Situation Awareness
SAALT	Secretary of the Army for Acquisition, Logistics and Technology
SACLOS	Semi-Automated Line of Sight
SADARM	Sense and Destroy Armor
SAR	Synthetic Aperture Radar
SARDA	Secretary of the Army for Research Development and Acquisition outdated, now SAALT Secretary of the Army for Acquisition, Logistics and Technology
SAS	Situation Awareness System
SBIR	Small Business Innovation Research

SES	Surface Effect Ships
SIGINT	Signal Intelligence
SIMNET	Simulation Network
SINCGARS	Single Channel Ground and Airborne Radio System
SIPE	Soldier Integrated Protective Ensemble
SLAD	Survivability and Lethality Directorate
SLID	Simple Low-cost Interception Device
SM	Signature Management
SRO	Strategic Research Objective
SSCOM	Soldier Systems Command
SSTOL	Super Short Take-Off & Landing
STARC	State Area Command
STI	Stationary Target Indicator
STO	Science and Technology Objective
STOW-E	Synthetic Theater of War-Europe
SUO	Small Unit Operations
SUOSAS	Small Unit Operations Situation Awareness System
SUSOPS	Sustained Operations
SWA	South West Asia
T&E	Test and Evaluation
TAA	Tactical Assembly Area
TAAD	Theater Area Air Defense
TACOM	Tank Automotive and Armaments Command
TAP	Technology Area Plan
TARA	Technology Area Review and Assessment
TARDEC	Tank Automotive Research Development and Engineering Center
TDA	Table of Distribution and Allowances
TENCAP	Tactical Exploitation of National Capabilities (program)
TERM	Tank Extended Range Munitions
TES	Tactical Engagement System; Tactical Engagement Simulation
TEU	20-foot-equivalent unit
TF	Task Force
THAAD	Theater High Altitude Defense System
TOC	Tactical Operations Center
TOR	Terms of Reference
TOW	Tube-Launched, Optically Tracked, Wire Command-Linked Guided
TPFDD	time-phased forces deployment data
TRADOC	Training and Doctrine Command
TRANSCOM	Transportation Command
TTP	Tactics, Techniques, and Procedures
TWG	Technology Working Group
TWS	Thermal Weapon Sight
UAV	Unmanned Aerial Vehicles
UGS	Unattended Ground Sensors

UGV	Unmanned Ground Vehicles
UHF	Ultra-High Frequency
USMA	United States Military Academy
USMC	United States Marine Corps
UV	Ultra-Violet
UWB	Ultra-Wide Band
UXO	Unexploded Ordinance
V/STOL	Vertical or Short Take-off and Landing
VCSA	Vice Chief of Staff of the Army
VISA	Voluntary Intermodal Shipping Agreement
VSAT	Very Small Aperture Terminal
VTOL	Vertical Take-off and Landing
VTOL JTR	Vertical Take-off and Landing Joint Tilt Rotor
WARSIM	Warfighter Simulation
WIN	Warfighter Information Network
WMD	Weapons of Mass Destruction
WRAP	Warfighting Rapid Acquisition Program

For Acronyms not found here, consult:

http://www.adtdl.army.mil/atdl/search/acronym.htm
or
http://www.sew-lexicon.com/

APPENDIX D

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